

Claims

- [c1] 1. A method for estimating a remaining operational life of a functional article after life-reducing utilization of the article has occurred which is at least partially attributable to loaded operation of the article, said method comprising:
- monitoring a functional article utilizing an operation in which at least two parameters associated with the article are assessed, said two parameters comprising a first parameter that causes operational life shortening degradation to the article and a second parameter that influences the rate of operational life shortening degradation caused by said first parameter, but alone does not cause operational life shortening degradation to the article;
- measuring, repeatedly, at least one of said parameters during operation of the functional article capable of assessing a total load in the article, wherein the total load represents a combined operational life shortening degradation of the article because of an interaction between the first and second parameters' combined influence on the article; and
- estimating the remaining operational life of the article based at least in part on a calculation including a product of values of the two parameters, the calculation representing an adjusted total load attributable to the article.
- [c2] 2. The method as recited in claim 1, wherein the adjusted total load is calculated a plurality of times during a time period during which the measuring of the at least one parameter is conducted.
- [c3] 3. The method as recited in claim 1, wherein the adjusted total load is calculated after each measurement of the at least one parameter.

- [c4] 4. The method as recited in claim 1, wherein calculated adjusted total load values are summed, and the result is stored in a first field of a memory unit.
- [c5] 5. The method as recited in claim 4, wherein summation of the adjusted total load values is carried out after each measurement of the at least one of said parameters.
- [c6] 6. The method as recited in claim 4, wherein, for subsequent calculations of the adjusted total load, the second parameter is assumed to be constant for a plurality of measurements of the first parameter, the adjusted total load is calculated with the second parameter at the constant value, and the calculated values for the adjusted total load are summed and the result is stored in a second field in the memory unit.
- [c7] 7. The method as recited in claim 1, wherein a number of load cycles of the first parameter is measured and a matrix in a memory unit is populated therefrom, said matrix comprising a plurality of different positions which each corresponds to a specific operational state and a specific operational condition, and the number of load cycles are cumulatively collected.
- [c8] 8. The method as recited in claim 1, wherein at least one of the first and the second parameters are described as an exponential function.
- [c9] 9. The method as recited in claim 1, wherein during the calculation of the adjusted total load, the first parameter is related to a condition between a measured second parameter and a reference value for the second parameter.
- [c10] 10. The method as recited in claim 9, wherein the reference value is

based on actual tests of the article.

- [c11] 11. The method as recited in claim 1, wherein a plurality of first parameters are measured in parallel, and the adjusted total load is calculated utilizing a function in which the life influence of each and everyone of the first parameters at the conditions are summed.
- [c12] 12. The method as recited in claim 1, remaining operation life of the article is calculated based on total load which is defined by total load relative to an initial damage tolerance of the article.
- [c13] 13. The method as recited in claim 1, wherein after a certain period of time, a total life influencing damage of the article is calculated as the sum of each of the previously calculated the adjusted total loads.
- [c14] 14. The method as recited in claim 13, wherein a value of the remaining life of the article is calculated based on total life influencing damage.
- [c15] 15. The method as recited in claim 1, wherein the adjusted total load on the article is calculated based on linear partial damage theory.
- [c16] 16. The method as recited in claim 1, wherein the adjusted total load on the article is calculated based on the Palmgren-Miner's partial damage theory.
- [c17] 17. The method as recited in claim 1, wherein the first parameter is measured with a higher frequency than the second parameter.
- [c18] 18. The method as recited in claim 1, wherein the article is a rotating object.
- [c19] 19. The method as recited in claim 1, wherein the article is arranged in a vehicle.

- [c20] 20. The method as recited in claim 19, wherein the article is a component in a gear box of the vehicle.
- [c21] 21. The method as recited in claim 19, wherein the article is a portion of a cardan shaft that defines an angular shift in the longitudinal direction of the shaft.
- [c22] 22. The method as recited in claim 19, wherein a result of the calculation of the adjusted total load is stored in a position in a memory unit of the vehicle.
- [c23] 23. The method as recited in claim 1, wherein the first and the second parameters are calculated from only one measured value and utilizing a mathematical algorithm.
- [c24] 24. The method as recited in claim 23, wherein the mathematical algorithm is representative of the Rainflow method.
- [c25] 25. The method as recited in claim 23, wherein the adjusted total load is calculated by means of a function which adjusts for the influence of the average tension on the effect of the amplitude of the tension.
- [c26] 26. The method as recited in claim 23, wherein the article is a part of a supporting structure of a vehicle.
- [c27] 27. The method as recited in claim 1, further comprising:
controlling subsequent use of the article based on the estimated remaining operational life of the article.
- [c28] 28. The method as recited in claim 1, further comprising:
valuing the article based on the estimated remaining operational life of the article.

- [c29] 29. The method as recited in claim 1, further comprising:
utilizing the estimated remaining operational life of the article as the basis
for dimensioning future articles which are intended to be exposed to
similar operation.
- [c30] 30. The method as recited in claim 1, further comprising:
utilizing the estimated remaining operational life of the article for
validating a simulation model of the article in operation.
- [c31] 31. The method as recited in claim 1, further comprising:
utilizing a difference in the estimated remaining operational life of the
article between delivery and return of the article to a user for calculating
charges to user for utilization of the article.
- [c32] 32. The method as recited in claim 31, wherein a signal comprising
information about the parameters and estimated remaining operational
life of the article is transmitted from a transmitter associated with the
article to a receiver associated with a base station located remotely from
the article, said signaled information being utilized for decision making
regarding measures to be taken with respect to the article.
- [c33] 33. The method as recited in claim 31, wherein the article is arranged in a
vehicle.
- [c34] 34. The method as recited in claim 1, information regarding remaining
operational life of the article is presented to a driver of the vehicle.
- [c35] 35. A system for communication between a base station and at least one
remotely positioned stationary or mobility fixed machine via transmitting
and receiving means for checking the operational status of the machine,
with the machine comprising an object that is susceptible to damage and

wherein the system further comprises a control unit, means for measuring a number of operational parameters of the object, and means for calculating damage done to the object based on the measured operational parameters.

- [c36] 36. The system as recited in claim 35, wherein the system further comprises a unit arranged to take steps for the future operation of the machine/object based on the calculation.
- [c37] 37. The system according to claim 36, wherein the unit for taking the steps is a station for spare parts, maintenance or restoration.
- [c38] 38. The system according to claim 36, wherein the unit for taking steps or measures is a facility for producing new objects.
- [c39] 39. The system according to claim 36, wherein the unit for taking steps or measures is an actuator arranged for influencing the operational condition of the object.
- [c40] 40. The system according to claim 35, wherein the system comprises means for storing a result of the damage calculation.
- [c41] 41. The system according to claim 35, wherein the machine is arranged in a vehicle, a vessel or a transport means which uses rails.
- [c42] 42. The system according to claim 35, wherein the transmitting and receiving means are arranged for transmitting information relating to the status of the machine via a transmission signal in the form of radio waves or via satellite communication.
- [c43] 43. A system for estimating a remaining operational life of a functional article after life-reducing utilization of the article has occurred which is at

least partially attributable to loaded operation of the article, said system comprising:

means for monitoring a functional article utilizing an operation in which at least two parameters associated with the article are assessed, said two parameters comprising a first parameter that causes operational life shortening degradation to the article and a second parameter that influences the rate of operational life shortening degradation caused by said first parameter, but alone does not cause operational life shortening degradation to the article;

means for repeatedly measuring at least one of said parameters during operation of the functional article capable of assessing a total load in the article, wherein the total load represents a combined operational life shortening degradation of the article because of an interaction between the first and second parameters' combined influence on the article; and
means for estimating the remaining operational life of the article based at least in part on a calculation including a product of values of the two parameters, the calculation representing an adjusted total load attributable to the article.